

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

"Made available under NASA sponsorship
in the interest of early and wide dis-
semination of Earth Resources Survey
program information and without liability
for any use made thereof."

7.9 100.16
CR-157905

(E79-10016) THE USE OF LANDSAT DATA FOR THE
ESTABLISHMENT, CONTROL AND SUPERVISION OF
PASTURE PROJECTS IN THE SOUTHEAST AMAZON
REGION (Instituto de Pesquisas Espaciais,
Sao Jose) 19 p HC A02/MF A01

N79-12530

Unclas
00016

CSCL 02F G3/43



CONSELHO NACIONAL DE DESENVOLVIMENTO CIENTÍFICO E TECNOLÓGICO

INSTITUTO DE PESQUISAS ESPACIAIS

1 - INTRODUCTION

The Superintendence for Amazon Development (SUDAM) is the Federal Agency responsible for the exploitation of the Amazon on a rational basis. SUDAM provides fiscal incentives to the ranchers who raise cattle on their ranches. One of the SUDAM responsibilities is to monitor deforestation for the establishment of artificial pastures.

A thorough knowledge of regional natural conditions is required, to select preferred areas for developing grazing lands, in order to preserve natural conditions in spite of the economical development.

The main objective of this study was to verify how the LANDSAT SYSTEM could be used to control and monitor pasture projects.

2 - MATERIALS

2.1 - TEST SITE

The region is located in the State of Mato Grosso, between latitudes $9^{\circ}00'$ and $16^{\circ}00'S$ and longitudes $50^{\circ}00'$ and $54^{\circ}00'W$.

Little or no information existed about the area and represented a typical situation in which there are problems of law enforcement.

The region has a tropical climate characterized by two well defined, dry and rainy, seasons (EMBRAPA, 1975). The regional geology has five principal units: Undifferentiated Pre-Cambrian, Sedimentary Rocks of the Paraná Basin, Tertiary and Quaternary Deposits and the Paraguai-Araguaia Folding Zone.

EMBRAPA (1975) confirms that this region presents a diversified vegetation, from Equatorial Forest to Grass Land.

ORIGINAL PAGE IS
OF POOR QUALITY

2.2 - MATERIALS

This study was carried out using LANDSAT SYSTEM products. Their description and specification can be found in NASA reports (1972).

For the visual data analysis, black and white images were used at the scales of 1:1,000,000, 1:500,000 and 1:250,000, for two different periods.

Channels 5 and 7 were used for visual analysis and CCT tapes were employed for automatic interpretation using IMAGE-100 (GE, 1975).

Topographic charts (1:1,000,000 and 1:100,000), computer programs, and field equipments were the auxiliary material for the study.

3 - RESULTS AND DISCUSSION

The objective of this study was to verify what kind of information could be obtained using the LANDSAT SYSTEM in order to orient the implantation of pasture projects in the Amazon Area. The obtained results and their applications are discussed as follows:

3.1 - DRAINAGE PATTERNS

Drainage patterns were analysed visually using channels 5 and 7.

Channel 7 imagery, acquired during the dry season, was used for mapping the drainage network in areas with dense vegetal cover. Dry season imagery had to be used because of humidity differences, in the spectral response, between Gallery Forest and adjacent forest.

Channel 7 images were shown to be the most adequate to identify and to map floodplains (Salomonson, 1973).

Channel 5 images were used to map secondary drainage in areas of less dense vegetal cover, because of the tonality differences between gallery forest and adjacent areas (Valerio et al, 1976).

The drainage map, at the scale of 1:1,000,000, allowed for the establishment of homogeneous hydrographical units. The objective of these units was to identify areas where superficial drainage conditions were propitious to the establishment of pastures.

Petrone (1970) and Keller (1970) reported that drainage pattern is one of the most important factors in creating pastures due to the water supply for cattle.

Quantitative analysis was made to map homogeneous hydrographical classes. Nine units were obtained, based upon drainage patterns and channel distribution.

The space between rivers is one of the most important factors in drainage network analysis. Topographical texture index was obtained for each homogeneous grouping, because it expresses the spacing from river to river (França, 1968). Freitas (1952), França (1968) and Koffler (1976) reported that areas with high values of topographic texture index are highly cut by channels.

Analysis of variance was applied to the topographic texture data. The results showed that there are significant differences among homogeneous hydrographical units at the level of 0.01.

Least Significant Difference test (Steel and Torrie, 1960) permitted the clustering of six homogeneous hydrographical units. The units were ranked in accordance with their potentials for establishing pastures.

Well drained areas, composed of average size rivers and regular spaced channels were classified as High Potential Units for

pasture establishment. They presented an average topographic texture index of 0.33 channel/km.

Dense drainage areas, with irregular spacing between rivers or predominantly sparse drainage areas, with rivers of average length, were classified as average potential units for pasture establishment.

Low potential units for development of pasture are characterized by: a) areas with numerous, short, regularly distributed and closely spaced ephemeral channels. These areas presented an average topographic texture index of 0.83 channels/km. b) areas with a few, long and irregularly distributed rivers. These areas were characterized by an average topographic texture index of 0.08 channels/km.

3.2 - VEGETAL COVER

In this work, the vegetal cover was classified to indicate areas where vegetation was favorable for establishing pasture projects.

A map, at the scale of 1:1,000,000, was made through visual analysis of the tonality. Channel 5 allowed the identification of tonal variations (Lee et al, 1974; Nossair et al, 1975 and Valerio et al, 1976).

Some kinds of vegetal cover affected by seasonal humidity changes could be classified through images acquired during the dry season. This classification was easily made because some species lose their leaves in the dry season, other species turn yellow and other remain green.

Channel 7 was useful for identifying vegetal cover units located in humid environments.

Channel 7 and 5 allowed the identification of homogeneous vegetation systems in accordance with tonal variation. During field work in the area under study (Tardin et al, 1976) interpretation keys were established for each homogeneous vegetation system.

The vegetation units were ranked in accordance with their potentials for initiating pasture projects. The several kinds of Cerrado* were included in the class with high potential for establishing pasture projects. In areas covered by Cerrado the establishment of the pasture is less expensive because the vegetal cover is easily felled.

Areas covered by Cerradão** and Sparse Forest (sparse and small diameter trees) were classified as regions with Average Potential for the establishment of pasture projects. These kinds of vegetal cover have low economical value for lumbering.

Dense Forest, Gallery Forest and humid grass land were included in the class with low potential for establishing pasture projects. Areas covered by dense forest must not be occupied with artificial pastures, because this kind of vegetal cover has high economic value for lumbering. The Gallery Forests should not be removed, for they protect the rivers. Flood areas have low potential because they can be occupied only in the dry season.

* Cerrado: vegetal cover characterized by three strata: the superior stratum formed by sparse, short trees (4 up to 6 meters of height); the intermediate stratum formed by shrubs of 1 up to 3 meters of height; lower stratum formed by grass and sparse short shrubs with little or no soil covering. Generally the trees are characterized by twisted trunks and coarse leaves covered by piles.

** Cerradão: this kind of vegetal cover is composed by three strata: the lower stratum formed by short trees; the intermediate stratum formed by shrubs and short trees with 5 up to 6 meters of height; upper stratum formed by trees with 10 up to 20 meters of height and without branches in most of their trunk.

3.3 - TOPOGRAPHIC CONDITIONS

Ground truth at the selected Roncador test site allowed us to observe the relationship between image texture variation in channel seven and topographic conditions.

The following parameters were selected to express topographic variation: Horton's Drainage Density Index (1945), França's modified Topographic Texture Index (1968) and the Declivity Index. The Roughness Index was calculated to express texture on LANDSAT images. This index is defined as a tonal variation within each spectral band (Haralick and Shanmugan, 1973). The tonal variation number within a sample represents the Roughness Index. All these parameters were collected using a 0.5 cm x 0.5 cm grid. (Evans, 1972 and Haralick and Bosley, 1973) in the scale of 1:1,000,000.

Nine texture classes were identified, through a visual analysis of the image texture, for the Roncador Test Site.

Parametric and non-parametric analysis for Roncador Test Site were done by two different methods: Correlation and Classification analysis, and Trend Surface Analysis.

Non-parametric tests were applied to perform correlation and classification analysis. Siegel (1956), Koch and Link (1971) and Doornkamp and King (1972) reported that those tests should be used when data distribution is unknown.

Wilcoxon's test (Steel and Torrie, 1960) was also applied to analyse the Roughness Index, Topographic Texture Index, Drainage Density Index and Declivity Index.

The imagery units could be clustered into six classes, according to the Roughness Index and into three classes, for the other indexes. Therefore, the Roughness Index presented the highest discriminating power to separate the photographic texture units.

Results showed that the Roughness Index could express texture variation in the LANDSAT image. The number of texture classes was reduced from nine to six. The reduction can be explained by the capacity of the human eye to register both small variation in the Roughness level, and differences in the texture patterns. The Roughness Index registered only the amount of tonal variation but not the tonal distribution pattern within a class.

Since the Roughness Index can represent photographic texture variation quantitatively, it was utilized to measure the relationship between image texture and the other parameters. Sperman's Correlation Coefficient (Steel and Torrie, 1960) was applied to the data.

The results showed that there is a high positive correlation between the Roughness Index, the Topographic Texture (0.90) and the Drainage Density Indexes (0.90). However, the correlation coefficient between the Roughness Index and Declivity Index (0.57) was low. This low value is not in accordance with theoretical studies which have already demonstrated that increases in topographic texture and drainage density values are related with increases in declivity values. (Freitas, 1952 and Christofolletti, 1974).

Trend Surface Analysis techniques were applied to verify whether the declivity data were affected by taking the same sample from the topographic chart and from the image at the scale of 1:1,000,000, due to small differences between the two. The methodology to perform the Trend Surface Analysis was suggested by Koch and Link (1971), Doornkamp (1972), Davis (1973) and Amaral (1976).

Three parameters were considered for Trend Analysis: Roughness, Topographic Texture and Declivity. The results showed that all the parameters had similar regional behavior. They showed a decrease in their values for the central part of the graph to the borders. Contour lines in the central position of the area were closely arranged, indicating greater variability of the topography.

These statistical surfaces express the real trend of the area. In fact, on the ground, the area is characterized by dissected topography at Roncador Scar. Topography gets lower from this zone toward the Araguaia Basin, at the east side, and toward the Xingu Basin, at the west side.

Data were also collected to verify the effect of the topographic chart scale on the relationship between Roughness and Declivity Indexes. Spearman's correlation coefficient increased from 0.57 to 0.72 with an increase in the chart scale. This can be explained by the fact that larger scale charts present smaller distance between contour lines, making declivity data more precise.

The variation coefficient, calculated for the declivity data was close to 40%. This large variability was related to the small image scale (1:1,000,000). The data were collected using a 0.5 cm x 0.5 cm grid. Because of the small scale, declivity data were collected for a large area on the ground where there was great topographic variation.

A LANDSAT image at the scale of 1:500,000 was used to collect Roughness data. With the larger scale, the square sample defined a smaller area on the ground. The average declivity angles became more representative. The Spearman's correlation coefficient value increased from 0.72 to 0.79 showing that image scale affects the relationship between Declivity and Roughness.

The results suggested that topographic units can be identified through the analysis of Roughness data.

Roughness data were, therefore, collected for the whole region, in order to map topographic variations.

Hierarchical Linkage Tree was applied to the data to obtain homogeneous Roughness classes. The Roughness classes were ranked in accordance with their potential for developing pasture projects.

Areas with high potential for development of pasture land were characterized by low Roughness values (12 tonal variations per sample), corresponding to regions with low declivity and dissection by drainage network.

A Roughness Index, with an average of 32 tonal variations per sample, characterizes regions with average values of declivity and drainage dissection which were classified as areas with Average Potential for the establishment of pasture projects.

Areas with low potential for pasture projects were characterized by High Roughness values (60 tonal variations per sample), corresponding to areas with steep slopes, deep valleys and dense drainage system.

3.4 - HIGHWAY NETWORK

Channel 5 images at the scale of 1:1,000,000 were used to identify highway networks. The necessary measurements, however, were made on images at the scale of 1:500,000.

Roads servicing areas with dense vegetal cover were easily identified in channel 5, because of contrast between the road bed and adjacent vegetal cover. During field work, it was observed that narrow and poorly conserved roads could not be identified on LANDSAT images. In some regions, roads were better identified on channel 7.

In areas covered by sparse vegetation, roads were not easily identified due to the smaller contrast (Malan et al, 1973). On the other hand, narrow roads with heavy traffic could be identified under dense vegetation cover.

The results demonstrated that LANDSAT image permitted the identification of only the main road system in the region. In the analysis of the network, therefore, it was decided that roads, not defined in the images, would not be included as part of the highway system.

The highway system was transformed into a graph, which allowed us to verify that the highway system had a low degree of connectivity.

The indexes α (0.26) and δ (0.51) (Taafée and Gauthier, 1973) allowed the classification of the network as a transition between spinal and grid networks. In accordance with Taafée and Gauthier the spinal stage represents the most primitive degree of a network development.

The shortest Path Matrix Technique permitted the Ranking of feasible pasture project based on connections and time spent to link each to the other.

These techniques demonstrated that the regions with better accessibility are placed where a great number of pasture projects have already been located.

Spearman's correlation coefficient between time and connection indexes showed that the projects with a high connection index are also better located based on the time index. The value of Spearman's correlation coefficient (0.93) showed that there is a strong relationship between time and connection indexes as indicator of accessibility. It was demonstrated that the road system was built to serve pasture projects and it has a cumulative effect in the highway system development.

Clustering Analysis classified the region under study based on Highway Network Density and Deforested Area Percentage.

The Cluster Analysis Program presented as an output a graph with clustering among the samples based on Highway Network Density and Deforested Areas Percentage. The resulting classes were ranked in accordance with their potential for the establishment of further projects.

The classes characterized by high highway network density (0.92 km/km^2) and low deforestation area percentage ($5\%/ \text{km}^2$) were included as classes with high potential for establishing pastures.

Classes with Average Potential for pasture development are characterized by high highway network density (0.92 km/km^2) and an average deforestation area percentage ($16\%/ \text{km}^2$).

Classes with Low Potential for pasture development are characterized by four cases:

- a) a low deforestation area percentage ($5\%/ \text{km}^2$) and low highway network density (0.18 km/km^2);
- b) a high deforestation area percentage ($27\%/ \text{km}^2$) and low highway network density (0.18 km/km^2);
- c) mean values of highway network density (0.55 km/km^2) and high deforestation area percentage ($27\%/ \text{km}^2$);
- d) high highway network density (0.92 km/km^2) and high deforestation area percentage ($27\%/ \text{km}^2$).

3.5 - DEFORESTATION CONTROL AND ASSESSMENT OF PASTURE QUALITY

One of the purposes of this research work was to verify the capability of the LANDSAT SYSTEM for deforestation control, in cattle ranches, and the assessment of pasture quality.

Two methods can be utilized to determine quantitatively the deforested areas: the visual and the automatic method. Comparison of the two methods, to determine the areas of deforestation for the 25 pasture projects, revealed that both gave almost identical results.

Evaluation of the deforested areas was faster by the visual method than by automatic interpretation. The main reason for this is that, due to sharp contrast between the forest and deforested

areas, the delineation of the pasture projects could be done visually using only two MSS bands (5 and 7).

The visual method was preferred for the monitoring of deforested areas, because it requires no expensive equipment.

The visual method consisted of placing a 1 millimeter dot grid over the 1:250,000 overlays relating to the area of each pasture project and counting the number of dots that fell inside each contour.

The results demonstrated that only a few projects are reaching the upper limit of deforestation permitted by law, not more than 50% of the natural forest of a property. It was also observed that several pasture projects had contiguous deforestations with more than 200 km². Due to a natural tendency of these projects to be established near one another so that they can share some of the service expenses, excessive deforestation is occurring in certain regions, and this may affect the local environment (Molion, 1975). It demonstrates that the laws to control deforestation are deficient. These laws do not state "how" to deforest so as to still protect natural conditions.

As a part of deforestation control, data were collected from August 1973 to June 1975. The results showed that, in absolute values, large areas were deforested during this period. Considering only the projects under study, there was an increase of 415 km² of deforested area in those 2 years.

During the field work (Tardin et al, 1976) it was observed that several deforested areas presented different pasture quality. Regrowth of natural vegetation was not significantly affected by the moisture. Even in the dry season, it did not lose its green color, as opposed to grasses, which turn yellow. This differentiation permitted the evaluation of the pasture quality which was performed in the Image-100.

As the regrowth of natural vegetation can be taken as an indication of bad pasture management, the pasture quality analysis permitted to verify whether deforested areas were being used in a rational way.

The Image-100 allowed the identification of two classes of pasture quality: pasture with a predominance of grasses and pasture with a predominance of natural regrowth.

The results showed that most projects have good pasture in only 50% to 70% of their deforested areas.

Considering that the total deforested area under this study is about 2,000 km², only 800 km² present conditions for grazing.

4 - CONCLUSIONS

The results obtained in this research showed that LANDSAT data can be utilized to develop monitoring programs in the Amazon Region.

This research did not exhaust the potential of the LANDSAT system, but tried to open new window for the utilization of LANDSAT data in natural resource control.